Projection of US Cancer Mortality and Incidence Rates in the late 2040s to early 2050s

Background:

For a planned Mars mission beginning in 2033, crew would return home around 2036 and face an increased lifetime risk of radiation exposure-induced death from cancer with a latency period on the order of 3 - 5 to 15 years or approximately between years 2040 to 2050. Additional missions are anticipated over the following 20 year period with the potential for late crew health risks from flights toward the end of the Mars campaign being of concern beyond the 2050s to 2070s. The current NASA lifetime risk of cancer estimate depends on several elements: (1) the radiation dose-response described by ERR and EAR models (from the Japanese Atomic Bomb LSS cohort), (2) the baseline rates of cancer incidence[1] and mortality[2] in the US population and, (3) a survival function calculated from US Life Tables[3]. Presumably, significant medical advances have the potential to impact both a reduction in baseline cancer rates as well as an increase in the survivability of the population. A reduction in baseline rates alone will lower lifetime risk, while an increase in survival will result in larger lifetime risk. Both must be considered in the current NASA risk modeling approach. (See attached SOW for further details)

Task:

The goal of this task is to gain a better understanding of how predicted clinical advances in medicine and increasing life span may alter cancer mortality rates in the 2040s to 2050 in future United States populations as well as projections into the 2070s. For example, a recent study suggests decreases in cancer incidence rates for men of 1.1% per year with incidence rates remaining stable for women, and a decrease in cancer mortality rates of 1.5% per year for both men and women over the last decade[3,4] with the exception of liver[5] and colon[6] cancers. Liver cancer has shown an increase in incidence and mortality for both men and women with age and ethnicity being critical factors.[5] Likewise, after decreasing in the previous decade, colon cancer incidence has increased from 0.5% to 1.3% since the mid-1990s in adults age 40 to 54 years.[6] However, new medical advances and research in personalized medicine may significantly impact these rates in the future. Ongoing developments in molecular biology and information technology make the reality of using vast amounts of genetic, ‘omics’, clinical therapy and environmental data in a revolutionary way to improve cancer surveillance, detection, and treatment. As these background population incidence and mortality rates are fundamental inputs to the NASA Space Cancer Risk Model (NSCR), significant advances in cancer survival will impact overall risk predictions to the crew and, therefore, mission design.

Task Deliverables:

1) Quantitative predictions for male and female cancer incidence baseline rates by cancer type over the next 15 to 50 years in US populations and the identification of factors most likely driving these changes.

2) Quantitative predictions for male and females describing survival post-cancer diagnosis by cancer type for present day and over the next 15 to 50 years in US populations for each survival interval between 1 year and 20 years (i.e., one year survival, two year survival, ….. 20 year survival). Survival probability estimates should emphasize cancer types that are most likely to benefit from advances in surveillance and treatment with consideration of the largest radiogenic risk contributors of lung, colorectal, leukemias, ovarian, breast, and liver cancers.

3) Estimates of US Life Tables over the next 15 to 50 years in future US populations.
4) The estimated impact of healthy lifestyle choices on background cancer incidence rates including reduction in smoking and exercise vs. increasing rates of obesity in the US population.
5) The identification of key advances (e.g. personalized medicine, advanced imaging and early detection, ‘omics’ and biomarkers, increased knowledge on individual susceptibility) that are most likely to contribute to the risk reduction of radiation-induced cancer incidence and mortality in future crews.
6) Assessment of the extent to which continued medical advancement between now and 2050-2070 will reduce cancer mortality and the likelihood that a major breakthrough can further reduce rates to an extreme low, listing all assumptions used in this assessment.

Based on the results of this task, NASA will predict the risk of radiation exposure induced death (%REID) for comparison with our current Permissible Exposure Limits (PELs) for future Mars Missions. This will require **four** data sets for 1-3 above that are directly relatable to current modeling approaches to project exposure risk for crew in the year **2033,** projections 10 to 15 years post-flight for the years **2045** and **2050,** as well as, projections into the **2070**s. Current modeling approaches require baseline incidence rates and survival probabilities for each cancer type described by sex-specific, single year age groups both in total and by cancer stage.

[1]United States Cancer Statistics: 1999 - 2010 Incidence, WONDER Online Database. United States Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; 2013. Accessed at http://wonder.cdc.gov/cancer-v2010.html on Jul 1, 2014.

[2]United States Cancer Statistics: 1999 - 2010 Mortality, WONDER Online Database. United States Department of Health and Human Services, Centers for Disease Control and Prevention; 2013. Accessed at http://wonder.cdc.gov/CancerMort-v2010.html on Jul 2, 2014.

[3]Elizabeth Arias, “United States Life Tables, 2009.” National Vital Statistics Reports, Vol. 62, No. 7, January 6, 2014. Revised_Tables_2009. Source: CDC/NCHS, National Vital Statistics System, Mortality.

[4]Annual Report to the Nation on the Status of Cancer, 1975-2010, Featuring Prevalence of Comorbidity and Impact on Survival Among Persons With Lung, Colorectal, Breast, or Prostate Cancer. Edwards et al; Cancer May 2014

[5]Annual Report to the Nation on the Status of Cancer, 1975-2012, Featuring the Increasing Incidence of Liver Cancer. Ryerson, et. al; Cancer May 1, 2016

[6]JNCI J Natl Cancer Inst (2017) 109(8): djw322; Colorectal Cancer Incidence Patterns in the United States, 1974–2013